Remarks

The Office Action mailed January 15, 2003 has been received and reviewed. Claims 10, 12-14 and 23 have been amended. Therefore, claims 1-50 are currently pending in the application. Reconsideration and withdrawal of the objections and rejections are respectfully requested in view of the above amendments and the following remarks.

Claims Objection

Claim 10 was objected to for claiming dependency to an inappropriate claim. Correction of the dependency has been made according to the Examiner's suggestion. As such, this objection is overcome. The other claims 12-14 and 23 have also been amended to correct for grammatical errors.

Claims Rejection - 35 U.S.C. §103 Rejection

The Examiner rejected claims 1-50 under 35 U.S.C. 103(a) as being unpatentable over Veerasamy et al. (U.S. Patent No. 6,447,891) in view of Miyawaki (U.S. Patent No. 5,543,648). Applicants respectfully traverse the rejection of the claims.

Veerasamy et al. describes a coating system for forming one or more layers. Veerasamy et al. teaches using a low energy electron flood gun in an XPS process to analyze the layer formed by the coating system. A general and conventional XPS analysis is performed.

Miyawaki does little more than describe various types of insulating films (e.g., SiO_xN_{1-x}) and the use of conventional XPS to evaluate certain properties thereof.

Claim 1 of the present invention describes a method for use in characterizing a sample, wherein the method includes providing calibration information representative of surface spectrum measurements for a plurality of samples correlated with depth profile information for the plurality of samples. Each of the plurality of samples is formed under a same set of process conditions and the depth profile information of each sample of the plurality of samples is provided using surface spectrum measurements corresponding to one or more progressively

deeper depths of each sample. The one or more progressively deeper depths result from removal of material therefrom.

Further, with reference to claim 1, the method includes performing one or more surface spectrum measurements for a sample to be characterized; wherein the sample is formed under the same set of process conditions. At least one characteristic of the sample to be characterized is determined based on the one or more surface spectrum measurements for the sample to be characterized and the calibration information.

Likewise, claim 22 describes a method for use in characterizing a sample comprising a thin film, wherein the method includes providing calibration information representative of surface spectrum measurements for thin films of a plurality of samples correlated with depth profile information for the thin films of the plurality of samples. Each of the plurality of samples is formed under a same set of process conditions. Further, providing the calibration information includes providing surface spectrum measurements for the thin film of each of the plurality of samples using a particular set of parameters. Providing the surface spectrum measurements includes irradiating the sample with x-rays resulting in the escape of photoelectrons therefrom, detecting photoelectrons escaping from the sample, and generating a signal representative of the detected photoelectrons. The surface spectrum measurements are based on the generated signals.

Further with reference to claim 22, providing the calibration information further includes providing depth profile information for the thin film of each of the plurality of samples, wherein providing the depth profile information comprises collecting depth profile data at each of a plurality of depths of the sample. Each depth corresponds to a sample surface and one or more of the plurality of depths of the sample are provided by removing material from the sample during material removal intervals resulting in sample surfaces at the one or more depths of the sample. Collecting depth profile data at each of the plurality of depths of the sample includes irradiating the sample with x-rays resulting in the escape of photoelectrons therefrom, detecting photoelectrons escaping from the sample, generating a signal representative of the detected photoelectrons, and using the depth profile data collected for at least a first and second depth to

generate at least a portion of the depth profile information. The second depth is at a position deeper in the sample than the first depth.

Yet further with reference to claim 22, with the calibration information provided, one or more surface spectrum measurements are performed for a thin film of a sample to be characterized using the particular set of parameters. The thin film is formed under the same set of process conditions as the thin films of the plurality of samples. At least one characteristic of the thin film of the sample to be characterized is determined based on the one or more surface spectrum measurements of the sample to be characterized and the calibration information.

Claim 35 describes a system for use in characterizing a sample, wherein the system includes an x-ray source operable to irradiate a sample with x-rays when the sample is positioned at an analysis plane of the system resulting in the escape of photoelectrons therefrom. An analyzer is operable to detect photoelectrons escaping from the sample; wherein the analyzer is operable to generate a signal representative of the detected photoelectrons. An ion source of the system is operable to provide ions for removal of material from a sample positioned at the analysis plane during material removal intervals resulting in sample surfaces at one or more depths of the sample.

Further with reference to claim 35, a computing apparatus is operable to recognize calibration information representative of surface spectrum measurements for a plurality of samples correlated with depth profile information for the plurality of samples, wherein each of the plurality of samples is formed under a same set of process conditions. The depth profile information is provided using surface spectrum measurements performed at one or more progressively deeper depths of each of the plurality of samples. The one or more progressively deeper depths result from the removal of material from the sample. The computing apparatus is further operable to generate one or more surface spectrum measurements for a sample to be characterized based on a signal representative of detected photoelectrons and determine at least one characteristic of the sample based on the one or more surface spectrum measurements for the sample to be characterized and the calibration information.

As such, each of the independent claims 1, 22, and 35 include similar limitations concerning the provision and use of calibration information, with claim 22 providing additional detail regarding the provision of such calibration information. For example, such claims describe calibration information representative of surface spectrum measurements for a plurality of samples correlated with depth profile information for the plurality of samples. Each of the plurality of samples is formed under a same set of process conditions and the depth profile information of each sample of the plurality of samples is provided using surface spectrum measurements corresponding to one or more progressively deeper depths of each sample. The one or more progressively deeper depths result from removal of material therefrom. With such calibration information provided, at least one characteristic of a sample to be characterized is determined based on the one or more surface spectrum measurements for the sample to be characterized and the calibration information.

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally the prior art references must teach or suggest all the claim limitations. *See* M.P.E.P. § 2143.

The cited references do not describe, teach or suggest all the claim limitations. For example, the cited references fail to describe, teach or suggest the calibration information as set forth in the claims, and as such, also the use of such calibration information in the determination of at least one characteristic of a sample to be characterized.

Veerasamy et al. simply teaches using a low energy electron flood gun to reduce surface electrical charging in an XPS process to analyze the layer formed by the coating system. The XPS analysis performed is conventional XPS processing and in no manner describes calibration information and use thereof as presented in the pending claims. For example, Veerasamy et al. does not describe calibration information representative of surface spectrum measurements for a plurality of samples correlated with depth profile information for the plurality of samples (i.e.,

the depth profile information of each sample of the plurality of samples provided using surface spectrum measurements corresponding to one or more progressively deeper depths of each sample). Therefore, such claimed calibration information is not used in Veerasamy et al. to determine at least one characteristic of a sample to be characterized.

Miyawaki does nothing to cure the deficiencies in Veerasamy et al. Miyawaki merely mentions the use of an XPS process (i.e., a conventional XPS process).

For at least the above reasons, claims 1, 22, and 35 are not obvious in view of the cited references. Further, the remainder of the rejected claims (i.e., claims 2-21, 23-34, and 36-50) respectively depend on one of the independent claims, either directly or indirectly. Therefore, they include the limitations of the respective independent claim upon which they depend. As such, these claims are also not obvious over the cited references for the same reasons as provided above.

If the Examiner has equated the calibration information as described in the claimed present invention with other information of the cited references, it is respectfully requested that such information used by the Examiner to show the claimed calibration information be specifically presented to the Applicants such that an appropriate response can be provided.

Summary

In view of the above amendments and remarks, reconsideration of the pending objections and rejections is requested. It is respectfully submitted that the pending claims are in condition for allowance and notification to that effect is respectfully requested. The Examiner is invited to contact Applicants' Representatives, at the below-listed telephone number, if it is believed that prosecution of this application may be assisted thereby.

Respectfully submitted for
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CERTIFICATE UNDER 37 CFR §1.8:
The undersigned hereby certifies that this paper is being transmitted by facsimile in accordance with 37 CFR §1.6(d) to the Patent and Trademark Office, addressed to Assistant Commissioner for Patents, Washington, D.C. 20231, on this 15 day of April 2003, at 10:10 am (Central Time).

By: [signature]
Name: SAM HER

APPENDIX A - SPECIFICATION/CLAIM AMENDMENTS
INCLUDING NOTATIONS TO INDICATE CHANGES MADE
Serial No.: 10/003,224
Confirmation No.: 5031
Docket No.: 278.00060120

Amendments to the following are indicated by underlining what has been added and bracketing what has been deleted.

In the Specification

The paragraph beginning at page 1, line 8, has been amended as follows:

Cross Reference to Related Applications

This is a continuation-in-part of U.S. Patent Application No. 10/075,571 [ ] filed on 26 October 2001 entitled "System and Method for Depth Profiling" which is [(Attorney Docket No. 278.00060101)] incorporated herein by reference.

In the Claims

For convenience, all pending claims are shown below:

1. A method for use in characterizing a sample, the method comprising:

providing calibration information representative of surface spectrum measurements for a plurality of samples correlated with depth profile information for the plurality of samples, wherein each of the plurality of samples is formed under a same set of process conditions, and further wherein the depth profile information of each sample of the plurality of samples is provided using surface spectrum measurements corresponding to one or more progressively deeper depths of each sample, the one or more progressively deeper depths resulting from removal of material therefrom;

performing one or more surface spectrum measurements for a sample to be characterized, the sample formed under the same set of process conditions; and

determining at least one characteristic of the sample to be characterized based on the one or more surface spectrum measurements for the sample to be characterized and the calibration information.

2. The method of claim 1, wherein the surface spectrum measurements for the plurality of samples are provided using a particular set of parameters, and further wherein providing the surface spectrum measurements for each of the plurality of samples comprises:

irradiating the sample with x-rays resulting in the escape of photoelectrons therefrom;

detecting photoelectrons escaping from the sample; and

generating a signal representative of the detected photoelectrons, wherein the surface spectrum measurements are based on the generated signals.

3. The method of claim 1, wherein providing depth profile information for the plurality of samples comprises providing depth profile information for each of the plurality of samples, wherein providing the depth profile information for each of the plurality of samples comprises:

collecting depth profile data at each of a plurality of depths of the sample, each depth corresponding to a sample surface, wherein one or more of the plurality of depths of the sample are provided by removing material from the sample during material removal intervals resulting in sample surfaces at the one or more depths of the sample, and further wherein collecting depth profile data at each of the plurality of depths of the sample comprises:

irradiating the sample with x-rays resulting in the escape of photoelectrons therefrom;

detecting photoelectrons escaping from the sample; and

generating a signal representative of the detected photoelectrons; and

using the depth profile data collected for at least a first and second depth to generate at least a portion of the depth profile information, wherein the second depth is at a position deeper in the sample than the first depth.

4. The method of claim 3, wherein providing the depth profile information for each of the plurality of samples comprises using depth profile data collected at a plurality of additional depths to characterize a certain thickness of the sample.

5. The method of claim 3, wherein the second depth is a depth at a sample surface resulting from removal of material from the sample during a material removal interval immediately following collection of depth profile data at the first depth.

6. The method of claim 3, wherein detecting photoelectrons escaping from the sample comprises:

providing an analyzer comprising an input lens receptive of photoelectrons, the input lens having a central axis extending therethrough; and

positioning the input lens such that the central axis of the input lens is at an analyzer angle relative to the sample surface, wherein the analyzer angle is in the range of about 45 degrees to about 90 degrees.

7. The method of claim 6, wherein the analyzer angle is in the range of about 60 degrees to about 90 degrees.

8. The method of claim 7, wherein the analyzer angle is about 90 degrees.

9. The method of claim 3, wherein removing material from the sample during material removal intervals comprises sputtering material from the sample using an ion beam provided at an ion angle less than or equal to about 45 degrees relative to the sample surface, wherein the ion beam comprises ions having ion energies of less than 500 eV.

10. (Once Amended) The method of claim <u>9</u> [10], wherein using the ion beam comprises providing the ion beam at an ion angle less than or equal to about 20 degrees relative to the sample surface.

11. The method of claim 3, wherein using the depth profile data collected for at least a first and second depth to generate depth profile information at the first depth comprises:

obtaining measured peak areas for at least one component from the depth profile data collected at the first depth, wherein the measured peak areas are representative of concentration contributions from a surface layer and also deeper layers of the sample, wherein the concentration contributions of the deeper layers are represented by the depth profile data collected at the second depth;

determining calculated peak areas for the at least one component corresponding to a measure of that component's concentration in the surface layer by removing concentration contributions of the deeper layers from the measured peak areas; and

converting the calculated peak areas into at least concentration of the at least one component at the first depth.

12. (Once Amended) The method of claim 1, wherein each of the plurality of samples [comprise] comprises a thin film having a thickness of less than about 10 [nanometer] nanometers.

13. (Once Amended) The method of claim 4, wherein each of the plurality of samples [comprise] comprises a thin film having a thickness of less than about 2 nanometers.

14. (Once Amended) The method of claim 13, wherein each of the plurality of samples [comprise] comprises a gate dielectric film.

15. The method of claim 13, wherein determining at least one characteristic of the sample to be characterized based on the one or more surface spectrum measurements of the sample to be characterized and the calibration information comprises determining at least the concentration of

one component of the thin film based on the one or more surface spectrum measurements of the sample to be characterized and the calibration information.

16. The method of claim 15, wherein determining at least one characteristic of the sample to be characterized based on the one or more surface spectrum measurements of the sample to be characterized and the calibration information further comprises determining at least the thickness of the thin film based on the one or more surface spectrum measurements.

17. The method of claim 16, wherein determining at least one characteristic of the sample to be characterized based on the one or more surface spectrum measurements of the sample to be characterized and the calibration information further comprises determining a degree of uniformity of thickness for the thin film across the sample to be characterized or a degree of uniformity of concentration of the at least one component across the sample to be characterized.

18. The method of claim 13, wherein each of the plurality of samples comprises at least a thin film of nitrided silicon oxide, and further wherein performing one or more surface spectrum measurements for the sample to be characterized comprises performing one or more surface spectrum measurements for a sample comprising at least a thin film of nitrided silicon oxide.

19. The method of claim 18, wherein determining at least one characteristic of the sample to be characterized based on the one or more surface spectrum measurements for the sample to be characterized and the calibration information comprises determining at least the concentration of nitrogen in the sample to be characterized based on the one or more surface spectrum measurements for the sample to be characterized and the calibration information.

20. The method of claim 19, wherein determining at least one characteristic of the sample based on the one or more surface spectrum measurements for the sample to be characterized and

the calibration information further comprises determining at least the thickness of the thin film of nitrided silicon oxide based on the one or more surface spectrum measurements for the sample to be characterized.

21. The method of claim 20, wherein determining at least one characteristic of the sample to be characterized based on the one or more surface spectrum measurements for the sample to be characterized and the calibration information further comprises determining a degree of uniformity of thickness of the thin film of nitrided silicon oxide across the sample to be characterized or a degree of uniformity of the concentration of nitrogen across the sample to be characterized.

22. A method for use in characterizing a sample comprising a thin film, the method comprising:

providing calibration information representative of surface spectrum measurements for thin films of a plurality of samples correlated with depth profile information for the thin films of the plurality of samples, wherein each of the plurality of samples is formed under a same set of process conditions, and further wherein providing the calibration information comprises:

providing surface spectrum measurements for the thin film of each of the plurality of samples using a particular set of parameters, wherein providing the surface spectrum measurements comprises:

irradiating the sample with x-rays resulting in the escape of photoelectrons therefrom;

detecting photoelectrons escaping from the sample; and

generating a signal representative of the detected photoelectrons, wherein the surface spectrum measurements are based on the generated signals; and

providing depth profile information for the thin film of each of the plurality of samples, wherein providing the depth profile information comprises collecting depth

profile data at each of a plurality of depths of the sample, each depth corresponding to a sample surface, wherein one or more of the plurality of depths of the sample are provided by removing material from the sample during material removal intervals resulting in sample surfaces at the one or more depths of the sample, and further wherein collecting depth profile data at each of the plurality of depths of the sample comprises:

irradiating the sample with x-rays resulting in the escape of photoelectrons therefrom;

detecting photoelectrons escaping from the sample; and

generating a signal representative of the detected photoelectrons; and

using the depth profile data collected for at least a first and second depth to generate at least a portion of the depth profile information, wherein the second depth is at a position deeper in the sample than the first depth;

performing one or more surface spectrum measurements for a thin film of a sample to be characterized using the particular set of parameters, the thin film formed under the same set of process conditions as the thin films of the plurality of samples; and

determining at least one characteristic of the thin film of the sample to be characterized based on the one or more surface spectrum measurements of the sample to be characterized and the calibration information.

23. (Once Amended) The method of claim 22, wherein the thin film of each of the plurality of samples [has] <u>comprises</u> a thickness of less than about 10 [nanometer] <u>nanometers</u>.

24. The method of claim 23, wherein the thin film of each of the plurality of samples comprises a gate dielectric film.

25. The method of claim 23, wherein the thin film of each of the plurality of samples comprises at least a thin film of nitrided silicon oxide, and further wherein performing one or

more surface spectrum measurements for a sample to be characterized comprises performing one or more surface spectrum measurements for a sample comprising at least a thin film of nitrided silicon oxide.

26. The method of claim 25, wherein determining at least one characteristic of the thin film of the sample to be characterized based on the one or more surface spectrum measurements and the calibration information comprises determining at least the concentration of nitrogen in the thin film of the sample to be characterized based on the one or more surface spectrum measurements and the calibration information.

27. The method of claim 26, wherein determining at least one characteristic of the thin film of the sample to be characterized based on the one or more surface spectrum measurements for the sample to be characterized and the calibration information further comprises determining at least the thickness of the thin film of nitrided silicon oxide based on the one or more surface spectrum measurements.

28. The method of claim 27, wherein determining at least one characteristic of the thin film of the sample to be characterized based on the one or more surface spectrum measurements and the calibration information further comprises determining a degree of uniformity of thickness of the thin film of nitrided silicon oxide across the sample to be characterized or a degree of uniformity of the concentration of nitrogen across the sample to be characterized.

29. The method of claim 22, wherein detecting photoelectrons escaping from the sample comprises:

providing an analyzer comprising an input lens receptive of photoelectrons, the input lens having a central axis extending therethrough; and

positioning the input lens such that the central axis of the input lens is at an analyzer angle relative to the sample surface, wherein the analyzer angle is in the range of about 45 degrees to about 90 degrees.

30. The method of claim 29, wherein the analyzer angle is in the range of about 45 degrees to about 90 degrees.

31. The method of claim 30, wherein the analyzer angle is about 90 degrees.

32. The method of claim 22, wherein removing material from the sample during material removal intervals comprises sputtering material from a surface of the sample using an ion beam provided at an ion angle less than or equal to about 45 degrees relative to the sample surface, wherein the ion beam comprises ions having ion energies of less than 500 eV.

33. The method of claim 32, wherein using the ion beam comprises providing the ion beam at an ion angle less than or equal to about 20 degrees relative to the sample surface.

34. The method of claim 22, wherein using the depth profile data collected for at least a first and second depth to generate depth profile information at the first depth comprises:

obtaining measured peak areas for at least one component from the depth profile data collected at the first depth, wherein the measured peak areas are representative of concentration contributions from a surface layer and also deeper layers of the sample, wherein the concentration contributions of the deeper layers are represented by the depth profile data collected at the second depth;

determining calculated peak areas for the at least one component corresponding to a measure of that component's concentration in the surface layer by removing concentration contributions of the deeper layers from the measured peak areas; and

converting the calculated peak areas into at least concentration of the at least one component at the first depth.

35. A system for use in characterizing a sample, wherein the system comprises:

an x-ray source operable to irradiate a sample with x-rays when the sample is positioned at an analysis plane of the system resulting in the escape of photoelectrons therefrom;

an analyzer operable to detect photoelectrons escaping from the sample, wherein the analyzer is operable to generate a signal representative of the detected photoelectrons;

an ion source operable to provide ions for removal of material from a sample positioned at the analysis plane during material removal intervals resulting in sample surfaces at one or more depths of the sample; and

a computing apparatus operable to:

recognize calibration information representative of surface spectrum measurements for a plurality of samples correlated with depth profile information for the plurality of samples, wherein each of the plurality of samples is formed under a same set of process conditions, and further wherein the depth profile information is provided using surface spectrum measurements performed at one or more progressively deeper depths of each of the plurality of samples, the one or more progressively deeper depths resulting from the removal of material from the sample;

generate one or more surface spectrum measurements for a sample to be characterized based on a signal representative of detected photoelectrons; and

determine at least one characteristic of the sample based on the one or more surface spectrum measurements for the sample to be characterized and the calibration information.

36. The system of claim 35, wherein the analyzer comprises an input lens receptive of photoelectrons, the input lens having a central axis extending therethrough, wherein the input lens is positioned such that the central axis of the input lens is at an analyzer angle relative to the

analysis plane, wherein the analyzer angle is in the range of about 45 degrees to about 90 degrees.

37. The system of claim 36, wherein the analyzer angle is in the range of about 60 degrees to about 90 degrees.

38. The system of claim 37, wherein the analyzer angle is about 90 degrees.

39. The system of claim 35, wherein ions provided by the ion source have ion energies of less than 500 eV.

40. The system of claim 35, wherein the ion source is operable to provide an ion beam at an ion angle less than or equal to about 45 degrees relative to the analysis plane.

41. The system of claim 40, wherein the ion source is operable to provide an ion beam at an ion angle less than or equal to about 20 degrees relative to the analysis plane.

42. The system of claim 35, wherein each of the plurality of samples comprises a thin oxide film.

43. The system of claim 42, wherein the thin oxide film is a thin nitride silicon oxide film.

44. The system of claim 35, wherein ions provided by the ion source comprise ions heavier than argon ions.

45. The system of claim 35, wherein the system further comprises means for rotating the sample during removal of material therefrom.

46. The system of claim 35, wherein the computing apparatus is operable to generate depth profile information for at least a first depth based on depth profile data collected for at least a first and second depth, wherein the second depth is at a position deeper in the sample than the first depth.

47. The system of claim 46, wherein the computing apparatus is operable to:

obtain measured peak areas for at least one component from the depth profile data collected at the first depth, wherein the measured peak areas are representative of concentration contributions from a surface layer and also deeper layers of the sample, wherein the concentration contributions of the deeper layers are represented by the depth profile data collected at the second depth;

determine calculated peak areas for the at least one component corresponding to a measure of that component's concentration in the surface layer by removing concentration contributions of the deeper layers from the measured peak areas; and

convert the calculated peak areas into at least concentration of the at least one component at the first depth.

48. The system of claim 35, wherein the computing apparatus is operable to determine at least the concentration of one component of a thin film of the sample based on the one or more surface spectrum measurements of a sample to be characterized and the calibration information.

49. The system of claim 48, wherein the computing apparatus is operable to determine at least the thickness of the thin film based on the one or more surface spectrum measurements.

50. The system of claim 49, wherein the computing apparatus is operable to determine a degree of uniformity of thickness of the thin film across the sample or a degree of uniformity of the concentration of the at least one component across the sample.